Answers to Chapter 7 Review Questions (Student textbook pages 482-7)

1. d 2. a 3. c 4. e 5. d 6. a 7. b 8. d 9. d 10. e 11. c 12. b 13. c

17. An increase in pressure will result in a shift to the left where there are fewer gas molecules.

18. This is a trick question because adding the Ar increases the total pressure but not the concentrations of the reacting gases (they aren't colliding with each other more, just Ar), therefore no effect.

23. At the beginning of the reaction, the concentrations of hydrogen and nitrogen were relatively high and the concentration of ammonia was zero. As the reaction proceeded, nitrogen and hydrogen combined to form ammonia. At the same time, ammonia decomposed to form nitrogen and hydrogen again. At some point in time, represented by the dashed line, the forward reaction rate and the reverse reaction rate were equal. The synthesis of ammonia occurred at the same rate as its decomposition and the system reached equilibrium.

24. The reaction shifts to the right at higher temperature. Therefore, according to Le Châtelier's principle, the reaction is endothermic.

26. Changes in pressure do not affect solids or pure liquids, as they are not compressible. As a result, a change in pressure does not affect the PbI2(s) or the water associated with the aqueous system. This means that the position of equilibrium will not be affected by any pressure change in this system.

27. As soon as the container is opened, the system is no longer closed and the gas will escape, thus preventing the reaction where this gas is a reactant from occurring. As a result, only the reaction that generates the gas can occur and thus the reaction is no longer at equilibrium.

28. a. $Keq = \frac{[CO_2]^3[H_2O]^4}{[C_3H_8][O_2]^5}$ b. $Keq = \frac{[NO]^2[H_2O]^2}{[N_2H_4][O_2]^2}$ c. $Keq = \frac{[Cu(NH_3)_4{}^{2+}]}{[Cu^{2+}][NH_3]^4}$

29. a. A large Keq value indicates that product formation is favoured.

b. If this process were to be reversed, reactants and products would be reversed, which would meanthe Keq expression would be the reciprocal of the original Keq expression. The reciprocal of a very large value is a very small value, so the reverse reaction would have a Keq value much smaller than 1.

30. The factors that can affect the equilibrium of a reaction are: the concentration of reactants or products; the pressure of a gaseous system where the number of gas molecules changes during the reaction; and temperature. Of these factors, only temperature affects the value of Keq.

32. $Keq = \frac{[NO_2]^2}{[N_2O_4]}$ b)

$$0.21 = \frac{[NO_2]^2}{4.18}$$

$$[NO_2] = \sqrt{(0.21)(4.18)}$$

$$= 0.94 \text{ mol/L}$$

33. a. reaction shifts to the right b. reaction shifts to the left c. reaction shifts to the right

34. $[CO_2] = \frac{1.41\ mol}{1.50\ L}$ $\quad$ $[H_2] = \frac{2.61\ mol}{1.50\ L}$

$= 0.94 \frac{mol}{L}$ $\quad$ $= 1.74 \frac{mol}{L}$

$$CO_2\,(g) + H_2\,(g) \rightleftharpoons CO\,(g) + H_2O\,(g)$$

I	0.94	1.74	0	0
C	$-x$	$-x$	$+x$	$+x$
E	$0.94-x$	$1.74-x$	$+x$	$+x$

$$K_{eq} = \frac{[CO][H_2O]}{[CO_2][H_2]}$$

$$0.74 = \frac{x^2}{[0.94-x][1.74-x]}$$

$$0.74 = \frac{x^2}{(1.63356-2.68x+x^2)}$$

$$1.21034 - 1.9832x + 0.74x^2 = x^2$$

$$0 = 0.26x^2 + 1.9832x - 1.21034$$

$$x = \frac{-1.9832 \pm \sqrt{1.9832^2 - 4(0.26)(1.21034)}}{2(0.26)}$$

$$= 0.568$$ $\quad$ x can't be $-$ve.

$[CO] = 0.568\ mol/L$

$n_{CO} = 0.568 \frac{mol}{L} \times 1.50\ L$

$= 0.85\ mol$

∴ there will be 0.85 mol at equilibrium.

35. a) $O_2(g) + 4HCl(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g)$

b) $$K_{eq} = \frac{[H_2O]^2[Cl_2]^2}{[O_2][HCl]^4}$$

$$= \frac{(7.8\times10^{-3})^2(3.6\times10^{-3})^2}{(8.6\times10^{-2})(2.7\times10^{-2})^4}$$

$$= 0.017$$

∴ Keq is 0.017

36. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\quad K_{eq} = 3.6\times10^{-3}$

I	3.8 mol/L	3.8 mol/L	0
C	$-2x$	$-x$	$+2x$
E	$3.8-2x$	$3.8-x$	$2x$

check approx

$$\frac{3.8}{3.6\times10^{-3}} = 1055$$

∴ x is small wrt to 3.8

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

$$3.6\times10^{-3} = \frac{(2x)^2}{(3.8-2x)^2(3.8-x)}$$

$$3.6\times10^{-3} = \frac{4x^2}{(3.8)^2(3.8)}$$

$$x = 0.2222$$

$[SO_3] = 2x$
$= 2(0.222)$
$= 0.44 \frac{mol}{L}$

∴ $[SO_3]$ is $0.44 \frac{mol}{L}$.

40. a) shift right ↑ $[H_2]$
b) shift left ↓ $[H_2]$
c) shift left ↓ $[H_2]$
d) shift right ↑ $[H_2]$
e) no change in equilibrium
f) no change
g) ↑V shift right ↑ $[H_2]$

43. $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

$$K_{eq} = \frac{\cancel{[NO]}^4[H_2O]^6}{\cancel{[NH_3]}^4[O_2]^5}$$

$$= \frac{(2.0)^6}{(3.0)^5}$$

$$= 0.26$$

∴ Keq is 0.26.

63. $2CH_4(g) \rightleftharpoons C_2H_2(g) + 3H_2(g)$

$$Q = \frac{[C_2H_2][H_2]^3}{[CH_4]^2}$$

$$= \frac{(15.74)(4.75)^3}{(4.76)^2}$$

$$= 74.45 < 702$$

$$Q < K_{eq}$$

b) $Q < K_{eq}$ the system lies to the left and will shift to the right.

64. $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

I	$0.80 \frac{mol}{L}$	$0.20 \frac{mol}{L}$	0
C	$-x$	$-x$	$+2x$
E	$0.80-x$	$0.2-x$	$+2x$

check approx

$$\frac{0.2}{1.1\times10^{-5}} = 18\,000 > 1000$$

$\therefore$ x is small wrt to 0.2 and 0.8

$$K_{eq} = \frac{[NO]^2}{[N_2][O_2]}$$

$$1.1\times10^{-5} = \frac{(2x)^2}{(0.80-x)(0.2-x)}$$

$$1.1\times10^{-5} = \frac{(2x)^2}{(0.8)(0.2)}$$

$$x = 6.63\times10^{-4}$$

$$[NO] = 2x$$
$$= 2(6.63\times10^{-4})$$
$$= 1.3\times10^{-3}\ mol/L$$

$\therefore$ [NO] is 1.3×10^{-3} mol/L at equilibrium

66. $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

I	$2.2782 \frac{mol}{L}$	0	0
C	$-2x$	$+x$	$+x$
E	$2.2782-2x$	$+x$	$+x$

$$K_{eq} = \frac{[H_2][I_2]}{[HI]^2}$$

$$0.022 = \frac{x^2}{(2.2782-2x)^2}$$

$$\sqrt{0.022} = \frac{x}{2.2782-2x}$$

$$0.14832 = \frac{x}{2.2782-2x}$$

$0.14832(2.2782-2x) = x$

$0.33788 - 0.29664x = x$

$0.33788 = 1.29664x$

$x = 0.2606$

$[H_2] = [I_2] = 0.261 \frac{mol}{L}$

$[HI] = 2.2782 - 2(0.2606)$

$= 1.76 \frac{mol}{L}$

$\therefore$ $[H_2]$ and $[I_2]$ is $0.261 \frac{mol}{L}$ and $[HI]$ is $1.76 \frac{mol}{L}$ at equilibrium